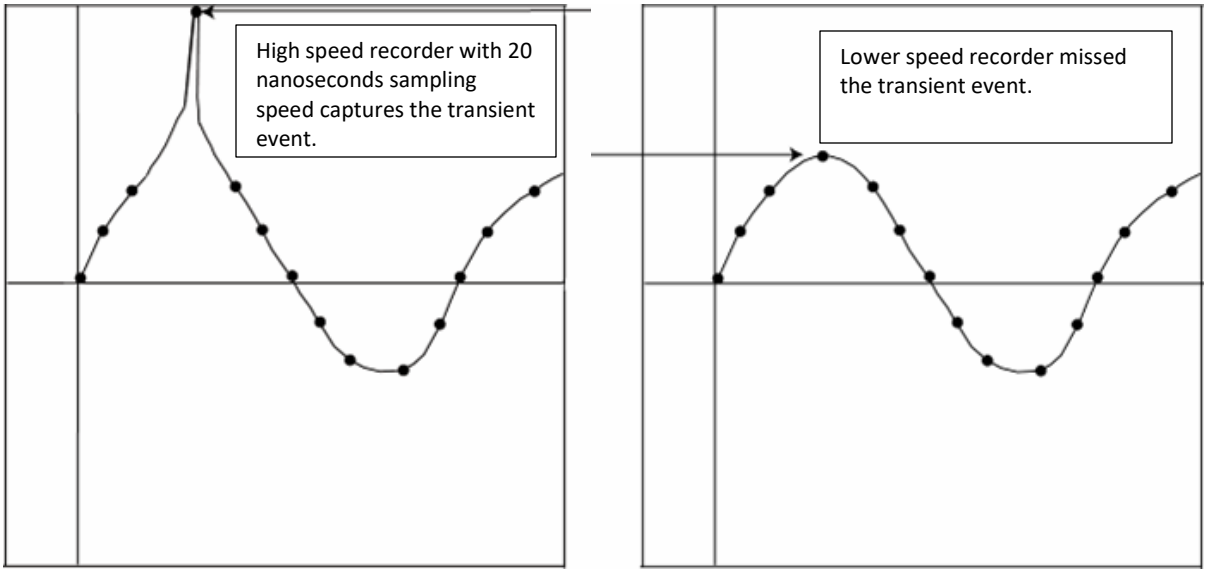
Addressing Transients in Transmission Lines

For the electrical grid to be operating efficiently, transmission lines from electrical utilities must operate in a steady state, without fluctuations in voltage and current flow. When there is a disturbance in this steady state, e.g., when there are transients, it is important to recognize and respond to them as soon as possible to maintain the optimal operation of the grid. Analyzing the cause of the transients can also help to prevent them in the future. This white paper looks at transient causes and effects, responses to transients, and the best way to measure transients in the electrical grid.

Firstly, transients as addressed in this paper are short term bursts of voltage and/or current that occur in a transmission line. They can be the result of internal conditions or external ones, e.g., transients can be "initiated due to disturbances like switching, occurrence of short-circuit faults or lightning discharge,"[i] resulting in a spike in voltage and/or current. In addition to reducing the operational efficiency of the grid, transients can cause damage if they are not mitigated. As described in a LinkedIn article on transients, the effects can range from "insulation breakdown, equipment failure, overheating, arcing, sparking" to "fire, noise, communication errors, data loss, or power quality degradation."[ii]

Because of the potential problems caused by transients, it is important to address them when they occur. Transient mitigation consists of restoring the steady state operation of the transmission line. Some methods of doing so include using devices such as "surge arresters, surge suppressors, filters, capacitors, reactors, transformers, or power conditioners. These devices can either divert, absorb, block, or modify the transients and surges to protect the grid and the equipment."[iii] These controls can be designed into the electrical grid. Using metering devices to set limits on voltage spikes can also enable protection schemes to be triggered.

Advanced power quality metering is an effective way of identifying and responding to transients in the system. Whether the transient is due to a lightning strike or a switching device, to activate response mechanisms, the transient must be identified by the metering device, which can either alert an operator for manual control or send a signal to an automatic control device. A potential problem with response to transients based on metering limits is the short duration of the transients. "According to ANSI standards, transient duration is about 1/16 times the time period of the voltage or current waveform, or about one millisecond. The typical duration of voltage transients is 50 microseconds and current transients occur for about 2 microseconds."[iv] However, many metering units do not have the capacity to measure transients. Legacy power meters aren't fast enough to capture a transient that occurs in a millionth of a second, does its damage, and disappears. Refer to the following figure.



Example of Blind Spots in Non-Transient Recording Meters

Both meters shown in the example have 1024 samples per cycle storage. However, the recorder on the left has a sampling rate as fast as 20 nanoseconds, so it captures the short term transient event that the other meter misses. Its faster speed can sample up to 1 million samples per cycle. An example of a high speed transient recorder is the Nexus® 1500+ power quality meter from EIG. It has a 50 MHz sampling rate on 4 phase voltages, so it can capture and record sub-cycle transients and help facility managers quickly get to the root cause of these events.

The Nexus® 1500+ meter is a certified Class A (as per IEC 61000-4-30:2015) power quality meter. In addition to its transient recording capability, it provides invaluable power quality analysis using the latest PQ standards to record electrical disturbances, improving power system reliability, and reducing downtime costs. It is also a precision revenue meter that collects energy usage with high accuracy. It is a cyber secured power quality meter, featuring multiport communication and is easy to install into existing infrastructure.

For more information on the Nexus® 1500+ power quality meter, visit:
https://www.electroind.com/products/nexus-1500-power-quality-meter-with-phasor-measurement-unit/

Notes

[i] "Electric Power Transmission and Distribution," *Transmission Line Transients*,. accessed 12/7/2023 from https://www.kuet.ac.bd/webportal/ppmv2/uploads/1502957755Transmission%20Line%20Transients.pdf.
[ii] "How do you monitor and diagnose transient and surge problems in electric grids?,: accessed 12/11/2023 from https://www.linkedin.com/advice/0/how-do-you-monitor-diagnose-transient-surge#solutions-for-transients-and-surges.
[iii] Ibid.
[iv] "Everything You Need to Know About Transients in Electrical Circuits," accessed 12/11/2023 from https://resources.system-analysis.cadence.com/blog/msa2022-everything-you-need-to-know-about-transients-in-electrical-circuits.